IMPACT
DFTM

1329

Draft for Region 6 Douglas-fir
tussock moth impact statement

Boyd E. Wickman

December 5, 1972

Impact of Defoliation on Trees

The Douglas-fir tussock moth can cause severe damage to Douglas-fir and true firs during outbreak populations. Douglas-fir and grand fir, the insect's principal hosts in Oregon and Washington, have reportedly suffered serious damage after past outbreaks (Keen 1952 and Wickman, et. al. 1971). Studies of California outbreaks in white fir occurring in 1935-37, and 1954-56 (Wickman 1958 and 1963) and in 1963-65 (Wert and Wickman 1970) have shown that immediate damage consists of tree mortality, radial growth reduction, and top-kill.

Tree Mortality

Research on the tree damage caused by defoliation has shown that when white fir stands are 75-100 percent defoliated for even 1 year, tree mortality can be very severe, averaging 30 percent of the stand by number and 20 percent by volume. The ranges of tree mortality from three study sites in California which suffered similar heavy defoliation, but had different age forests are shown below. 1/

	Mortality by stand age			
Host age class	Old growth		Second growth	
	percent of class	Bd. ft./ acre	percent of class	Bd. ft./ acre
Reproduction	45	--	33	--
Saplings-Poles	50	--	36	--
Sawtimber	20-29	10,000-11,000	25-32	2,518

There are three important factors, all related to tussock moth population dynamics, to consider when determining amounts of tree mortality. They are distribution of killed trees in the stand, timing and amount of defoliation, and the ultimate cause of death.

1/ Data from studies by Wickman 1963 and Wert and Wickman 1970.

1. Severe defoliation and resultant tree mortality does not occur uniformly over the stand. Some scattered groups of trees have higher tussock moth populations than others and often these trees occur in clumps 1 to 50 acres (sometimes larger) in size. The really significant damage occurs in these clumps, which may have up to 94 percent tree mortality.

Results of a sample of group tree mortality after a severe outbreak are given below. 2/

White fir (1-30" dbh) killed after Douglas-fir tussock moth defoliation -- 1965-67, Stowe Reservoir, California

Group no.	Acreage	Dead stand/acre No.	Green stand/acre No.	Percent of stand killed/acre
1	2.5	305	85	78.2
2	5.75	369	24	93.9
3	1.0	224	58	79.4
4	3.5	259	55	82.5
5	4.0	319	61	83.9
Total	21.5	1,476	283	
$\bar{x}$	4.3	295.2	56.6	83.9

Tree mortality on the entire outbreak amounted to 32 percent of the stand or 2,518 board feet per acre. But the clumped tree mortality was concentrated on 14 percent of the timbered area and contained 40 percent of the total outbreak mortality.

2. Tree mortality is a function of defoliation caused by certain population levels. Historically and through sampling studies Douglas-fir tussock moth has been noted severely defoliating trees in one year of feeding (Wickman et al. submitted for publication). This defoliation has been so rapid and complete that it has been referred to as an "explosive" outbreak. Most of the total tree damage can be associated with this first year of severe defoliation. The next year a large outbreak has inevitably delined due to a natural virus disease. There is additional feeding during the year of population decline, but comparisons of total tree mortality and top-kill on untreated areas and these treated with DDT at the second year of heavy feeding have not shown significant differences.

2/ Unpublished data, B.E. Wickman, on file Forestry Sciences Laboratory, U.S. Forest Service, Corvallis, Oregon.

There is also a consistent relationship of percent of tree crown defoliated with subsequent tree mortality (Wickman 1963). Trees with less than 50 percent defoliation often suffer little mortality. Comparisons of tree mortality by percent defoliation is shown below for treated and untreated outbreaks. 3/

	Defoliation classes (Percent crown defoliated)				
Outbreak areas	5-25	50	75	90	100
	Percent mortality				
Untreated:					
Mammoth Lakes	2	8	----41----*		100
Roney Flat	0	0	0	56	100
Treated: (in second year of outbreak)					
Stanislaus	2	22	40	65	100
Stowe Reservoir	0	4	0	60	100
Toms Creek	0	0	0	24	100

* Data for 2 classes combined.

3. There are two main causes of tree death from the effects of tussock moth feeding. The first, mortality due to defoliation alone, shows up the year after severe defoliation. Most of this occurs in sub-merchantable size trees e.g. .5 and 12.2 percent of the green stand volume in 2 outbreaks studied (Wickman 1963).

Beetle attacks on trees weakened by defoliation were the second cause of death. Two beetle species have been responsible: The fir engraver, Scolytus ventralis Lec., and the roundheaded fir borer, Tetropium abietis Fall. In one outbreak three quarters of the total mortality was caused by beetles (Wickman 1958). Some of the trees that died from this cause might have died from the effects of defoliation alone if they had not been attacked by beetles, but conversely many trees that could have survived the effects of defoliation were killed by increased beetle populations in the outbreak areas. This type of mortality continues for four years after defoliation and occurs mostly in merchantable size trees.

3/ Wickman 1963 and unpublished data, B.E. Wickman, on file, Forestry Sciences Laboratory, U.S. Forest Service, Corvallis, Oregon.

Top-Kill

Where defoliation is not severe enough to kill the trees completely, the upper part of the crown often dies. Top damage is most prevalent in sawtimber size trees that have been severely defoliated. This type of damage has occurred on 12-14 percent of the total merchantable timber on heavily defoliated areas. 3/ However, as many as half the trees in the 50-75 percent defoliation class have suffered top-kill. 2/

Death of the terminal shoot often occurred in smaller trees. Many of these damaged trees subsequently developed new leaders from lateral branches.

In a recent study the threat of defect due to decay organisms in top-killed poles and small sawtimber was not economically serious 33 years after being top-killed (Wickman and Scharpf 1972).

Radial Growth

Annual ring patterns in sample discs cut on outbreak areas have shown that defoliation has both immediate and pronounced effects on radial growth (Wickman 1963). Normally, the annual ring for a given year is wider in the upper part of the stem than at the base, and ring measurements for the years preceding an outbreak showed this to be true.

Immediately after an outbreak, the growth patterns change. Defoliation has caused significant decreases in ring width at all levels examined, but the magnitude of the decrease was proportionally greater in the upper part of the tree where feeding damage was heaviest. The average reduction during the 3 years of greatest growth depression, calculated as a percentage of the growth during the 4 years immediately preceding, was as follows: heavy defoliation, 74 percent; moderate defoliation, 67 percent; light defoliation, 31 percent. Growth recovery was not complete until the fourth and sometimes the fifth year.

When this growth reduction was translated into terms of board feet for all merchantable size trees on one heavily defoliated area, actual growth was only 36.5 percent of expected growth during the three year period for a total growth reduction of 63.5 percent (Wickman 1963).

Long-term growth effects on heavily defoliated areas have shown the reverse of the immediate short-term growth reductions. On one area heavily defoliated 35 years ago the growth of individual trees showed an increase for the 33-year period after defoliation compared to a similar period before defoliation (data from Wickman and Scharpf 1972).

If the stand is understocked due to heavy tree mortality this growth increase for survivors may not equal the total expected growth per acre. Salvage of the dead trees will reduce the total loss in terms of growth of the stand. However, if surviving trees represent an adequate stocking level, then the salvage plus the long-term growth increase could be a significant benefit.

SIMILAR TO THINNING ?

LITERATURE CITED

Keen, F.P. 1952. Insect enemies of western forests. USDA Miscell. Publ. No. 273. 280 p. illus.

Wert, S.L. and Boyd E. Wickman. 1970. Impact of Douglas-fir tussock moth . . . color aerial photography evaluates mortality. USDA Forest Serv. Res. Pap. PSW-60, 6 p. illus. Pac. SW Forest & Range Exp. Stn., Berkeley, Calif.

Wickman, Boyd E. 1958, Mortality of white fir following defoliation by the Douglas-fir tussock moth in California, 1957. USDA Forest Serv. Res. Note No. 137, 4 p. Pac. SW Forest & Range Exp. Stn., Berkeley, Calif

_______________ 1963. Mortality and growth reduction of white fir following defoliation by the Douglas-fir tussock moth. USDA Forest Serv. Res. Pap. PSW-7, 15 p. Pac. SW Forest & Range Exp. Stn., Berkeley, Calif.

_______________, G.C. Trostle and P.E. Buffam. 1971. Douglas-fir tussock moth. USDA Forest Serv., Forest Pest Leafl. 86, 6 p. illus.

_______________ and Robert F. Scharpf. 1972. Decay in white fir top-killed by Douglas-fir tussock moth. USDA Forest Serv. Res. Pap. PNW-133, 9 p. Pac. NW Forest & Range Exp. Stn., Portland, Ore.

_______________, R.R. Mason and C.G. Thompson. USDA Forest Serv., Pac. NW Forest & Range Exp. Stn., submitted for publication.